10/590615
IAP9 Rec'd PCT/PTO 25 AUG 2006

Piston Pump for Thick Materials

The present invention regards a pump for thick materials with features according to the non characterizing part of patent claim 1. In a broader sense it also regards the controls of such thick materials pumps.

Thick materials piston pumps have been used for a long time in particular at construction sites to feed concrete. Usually they are provided as hydraulically operated piston pumps, mostly with two cylinders, feeding concrete through hoses or pipes. Subsequently, in a simplified manner, concrete feeding is being referred to. The invention is not limited to an application with concrete feeding pumps but can be used for all similar thick materials pumps.

Such pumps have to fill a single feed line with two alternatively filled cylinders and associated pistons. The respectively filled cylinder is being connected with the feed line via a moveable pipe switch. Subsequently the piston pushes out the concrete (pump stroke), while the parallel piston is being retracted, in order to fill the cylinder with concrete again (suction stroke). At the end of each stroke the moving direction of the cylinder pistons is reversed and the pipe switch is shifted, so that pump strokes and suction strokes alternate continuously. The two pump pistons are preferably driven hydraulically coupled amongst each other, so that they basically work in a counteracting manner.

Common pipe switches (DE 29 33 128 C2) are arranged, so that they can be switched back and forth between two end positions, wherein they alternatively establish the connection between the cylinder openings and the feed line on the one hand, and the pre filling container on the other hand. From this results a discontinuous feeding.

US 3,663,129 describe a concrete pump with continuous feeding, wherein the shift valve or its pipe switch consists of a so called sleeve slide. Its waist opening is con-

tinuously but pivotally connected with the mouth of the feed pipe as a downstream outlet. Its kidney shaped inseam opening (inlet, upstream) is long enough to cover the openings of both pump cylinders simultaneously. During the operation the pipe switch performs a continuously oscillating pivoting motion, whose axis is coaxial with the mouth of the feed pipe. The pivoting angle of the pipe switch is approximately 50° towards both sides from the middle.

The pistons of the pump cylinders are controlled depending on the momentary position of the pipe switch, so that in the moment when both cylinder openings are covered by the sleeve opening, one cylinder is at the end, and the other cylinder is at the beginning of a pump stroke. Thereby the feeding action continuously shifts from one cylinder to the other. In the state of the art control system for the suction stroke and for the pump stroke of each cylinder the same time span is used. Therefore there is no simultaneous feeding of both cylinders.

Due to the one sided bearing of the state of the art pipe switch on the side of the feed pipe and due to the enveloping support and sealing surfaces only surrounding the sleeve opening, the substantial tilting moments of the state of the art design can not be completely received. It can not be excluded, that due to gap formation substantial leaking losses occur in the seal area between the sleeve opening of the pipe switch and the feeding cylinders, which in turn denies the realization of a really continuous feed action.

The British Patent 1,063,020, as a gender defining state of the art describes a multi cylinder thick materials and concrete pump, whose shift valve in one embodiment comprises two rotating slides, (also formed as sleeve valves), each controlled by a lifting cylinder of their own. Their outlet ports are connected with a common Y-tube, which in turn is connected to the feed line downstream. Each rotating slide can either work together with a single, or with two pump cylinders. Though synchronous control of the rotating slides is mentioned, however with this state of the art pump and control system continuous feeding of the feeding cylinder into the common feed line is neither intended nor possible.

DE 30 06 542 C2 describes a guillotine flat valve for two cylinder thick materials pumps. It comprises a guillotine flap solidly connected with a control rod, which can be alternately moved back and forth between two end positions in a guide housing or -frame. This state of the art 2/2 way guillotine valve can also be installed between the flanges of a Y-tube and an intake or exhaust tube. In concrete pumps it is preferably installed between the bottom of a prefilling container and the exhaust pipes of a two-cylinder piston pump and/or the feed line and the exhaust pipes.

Furthermore it is also state of the art, to provide thick materials pumps of the kind that is being discussed here, with an insertion station, through which a cleaning body for removing unused thick materials, which have remained in the feed line, can be inserted. This insertion station comprises e.g. a chamber slide, moveable by a motor or hydraulically, with at least two chambers of equal cross section. In the resting position of the insertion station the one chamber forms a section of the feed line, while the other chamber is freely accessible. Into the latter the said cleaning body can be manually inserted from the outside. For a cleaning procedure, with the thick materials pump shut down, the insertion station is shifted into a working position, wherein the chamber containing the cleaning body replaces the other chamber within the feed line. Then the cleaning body can be pressed through the feed line with compressed air, whereby it pushes the thick material ahead of itself. These state of the art insertion stations, however have to be provided in addition to the shift valve discussed above.

The objective of the invention is to provide an improved thick materials pump and a process for controlling a thick materials pump with continuous feeding.

This objective is accomplished according to the invention with the features of patent claim one, with respect to the control process with the features of the independent claim 19.

The features of the dependent claims associated with the independent claims provide advantageous improvements of the invention.
While with the pumps according to the above explained U.S. and GB patents the control slides are mostly located at the thick materials container in an exposed manner, through providing the shift valve with two translatorically movable, in particular linear guided control slides, an embodiment, less exposed to the thick material especially to the concrete, can be created for the preferred application. On the one hand this is valid for abrasive uses, but also for loading through dynamic pressure in the feed line or in the feeding cylinders. In the area of the control slides the thick material is, different from the known sleeve slides, not redirected under pressure, but substantially run through the tubing sections in a straight manner. Only in the collector tube (also Y-tube) the concrete flows from the feeding cylinders are merged. This substantially contributes to the pressure relief of the slides themselves and does not only reduce the loads on the bearings, but also reduces the frictional forces when switching the control slides. Consequently this engineering solution noticeably reduces mechanical wear of the moveable and non moveable parts of the shift valve.

It should be noted that, though a two cylinder thick materials pump is discussed here in an a preferred embodiment, the design according to the invention can also be transposed to pumps with three or more cylinders, wherein a control slide would have to be associated with each feeding cylinder.

It is not absolutely necessary to guide the control slides in an exactly linear manner, but according to the invention a slight arc can be provided, whereby the major part of the motion remains translatoric.

Though it is conceivable to support the parallel control slides directly at the surfaces facing each other, preferably however the guidance structure for each control slide will have a dedicated slide rail allowing larger offsets of the control slides during their operational cycles.

For providing the shift valve (guidance structure and control slide) with sliding guides with friction and abrasion resistant materials and possibly with wear parts known means can be applied, so this does not need to be discussed in detail. The same applies for the seals between the control slides and the openings of the feeding cylinders and the collector tube.

According to the invention it is advantageous, when the control slides can occupy three different positions, a transfer position, a blocking position and an inlet position. To these three positions corresponds a design or a subdivision of the control slides into three different sections, this means a transfer section, a blocking section and an inlet section. The names of the sections or positions are self explanatory and will be discussed in connection with the description of the attached figures.

It is advantageously possible to provide / prefabricate the above mentioned sections as single modules and assemble them in the required order. Overall a control box or a control cage with the necessary valve travel or functions is created. This design can favor the simple replacement of single, prematurely worn or damaged sections, in particular when connections are provided amongst them, that can be disassembled.

It is understood that the two control slides are advantageously provided identical amongst each other; variations can result from space constraints, when attaching the respective drive systems.

A substantial advantage of the solution according to the invention is the simply applicable option to use at least one, possibly both control slides of the shift valve also as insertion station(s) for the cleaning bodies. The short tubing sections of the control slides and the feed line have to be cleaned during operation shut down of the pump, this means residual thick material or concrete leftovers have to be removed.

For this purpose the invention provides access to the control slides. This can be provided e.g. through flaps, which are normally closed, but provide access to the control slides after opening.

For this a separate cleaning- or insertion position of the control slide(s) can be provided. According to an advantageous refinement, however the inlet position of the control slide is used as insertion position for the cleaning bodies at the same time. This is possible, because in this inlet position the tubing cross section of the control slides is without function and also without pressure.

Based on the state of the art initially discussed such a combination is neither provided, nor easily possible.

As drives for the control slides preferably hydraulic positioning cylinders are used. However other suitable drives, e.g. electric motors, linear gear drives, etc. can be used.

In a first practical embodiment two serially coupled (working both ways) lifting cylinders can be used. In this configuration the stroke of each of the cylinders corresponds to the shifting distance of the associated control slide from one position into the next. When both cylinders are completely retracted, the control slide is in its lowest position (e.g. inlet position). When a cylinder is extended, the control slide moves into its middle position (e.g. blocking position). When also the second cylinder is being fully extended the control slide reaches its top position (e.g. the transfer position).

It is understood that the same effect can also be accomplished with a two stage lifting cylinder (telescoping cylinder), whereby its middle position, however has to be exactly controllable and lockable, in order to assure defined shifting positions of the control slides.

Besides locking the respective positions of the control slides directly and only through their drives, dedicated locking mechanisms certainly can also be provided, preferably engaging directly between the guidance structure and the control slides. These locking mechanisms can also be operated remotely, this means engaged and disengaged. Furthermore it is also conceivable to spring load such locking mechanisms in locking direction, so that they lock by themselves when the control slide moves into the position to be fixated.

In case the above mentioned drive lifting cylinders are not to be located coaxial with the control slides, e.g. because of space constraints, they can be located parallel next to the control slides. In this case a load transfer in a perpendicular direction between the control slides and the rod end pieces of the lifting cylinders has to be provided, e.g. a cross beam or a console. For this a respective opening in the guidance structure for the control slides must be provided, so it can follow the lateral movements of the slides.

Depending on the mounting conditions, the lifting cylinders can also be located at an angle relative to the control slides, if a suitable lever- or angular gear system can be installed for adjusting the respective control slide positions.

Further details and advantages become evident from the drawing of an embodiment and it's following detailed description.

In a highly simplified and purely schematic illustration it is shown in:

Fig. 1 a perspective view of the assembly of the thick materials pump with additional functional components;
Fig. 2 a cross section side view of the thick materials pump with a multiple control slide shift valve according to the invention;
Fig. 3 a cut view through the middle axis of the feeding cylinders of the thick materials pump according to Fig. 2 (line II–II) for emphasing the location of the feeding cylinder, the shift valve and the collector tube;

Fig. 4 a frontal view, tilted by 90° relative to Fig. 2 (cut along the line III-III in Fig. 1) of the shift valve with two parallel control slides;
Fig. 5 a time-distance-diagram of the phase shifted strokes of both pistons of the thick materials pump relative to the respective positions of the two control slides;
Fig. 6 a first drive variant for a control slide, comprising two hydraulic lift cylinders in tandem arrangement;
Fig. 7 a second drive variant for a control slide comprising a telescopic cylinder, extendable in two stages, and
Fig. 8 a third drive variant for a control slide comprising a single long stroke lifting cylinder

Fig. 1 shows the perspective outlines of a thick materials pump 1 with two parallel feeding cylinders 3 and 5, lying next to each other, a prefilling container 7, a shift valve 9, a collector- or Y-tube 19, as well as a short section of a feed line. The shift valve is located in a housing, or in a guidance structure 11, reaching through the bottom of the prefilling container 7. Close to the bottom of the guidance structure, on the side facing the feeding cylinders 3 and 5, a maintenance flap 13 is provided. Above the prefilling container, like an explosion drawing two control slides 15 and 17 are shown, which are intended for moveable insertion into the housing shaped guidance structure 11 of the shift valve 9, forming its valve body. This will be subsequently explained in detail.

Fig. 2 only shows the feeding cylinder 3 of the thick materials pump 1, which is located in the front of this view, in the area of its open (exhaust) end. The associated piston is not shown. The second feeding cylinder 5 is located behind the feeding cylinder 3 and covered in viewing direction. It is visible again in Fig. 3 from the top. Both pistons of the feeding cylinders 3 and 5 are driven independently from each other (preferably hydraulically) and can in principle operate at any relative position or velocity within the limitations of their strokes and their control systems. However it is also possible to operate them in hydraulically coupled manner. Both cylinders and pistons have the same diameter, e. g. 250 mm.

The funnel shaped prefilling container 7, of which only the lower part (bottom part) is visible, is open at the top and is bolted to the open ends of both feeding cylinders 3 and 5. The thick material to be supplied by the thick material pump is poured into it from the top. The openings of both feeding cylinders 3 and 5 exit in the lower area of the prefilling container 7. Thereby a maximum filling level of thick material remains above the cylinder openings when thick material is sucked into the feeding cylinders.

In the bottom of the prefilling container 7 a shift valve designated 9 in its entirety is located in a known manner. Only through this shift valve 9 the thick material reaches the feeding cylinders 3 and 5, and only via this shift valve the feeding cylinders eject the thick material into the feed line, which is not shown, as will be described in detail later.

The shift valve 9 comprises a nonmoving guidance structure 11, which is mounted solid to the prefilling container 7. It protrudes to a certain extent upwards into the prefilling container, and also reaches downwards through its bottom.

It should be noted, that in this example only a vertical installation of the guidance structure is referenced. However this is not mandatory.

In principle the guidance structure 11 can be provided as an open frame, in particular shaped like a shelf. Preferably it is constructed as a substantially closed box with several functional openings, which in particular in its upper area which is located in the prefilling container, is kept open far enough in order to provide an undisturbed inflow of the thick material to the shift valves, also directly at the bottom of the prefilling container. Thereby, besides an upper opening also an open side, e.g. towards the feeding cylinders can be advantageous, without thereby compromising the exact guidance of the control slides in this area.

In the lower section of the guidance structure 11, outside the prefilling container 7 a flap 13 is located, which is normally closed. By opening the flap 13 access to the

interior of the guidance structure 11 is provided, which is shaped like a box or a housing in the embodiment shown.

The latter forms a linear guide for the two control slides 15 and 17 (the latter is visible in Fig. 1, 3 and 4, and Fig. 2, it is covered however as well as the feeding cylinder 5). These provide the connection between the feeding cylinders on the one hand and a collector tube 19 on the one hand, and the feed line connecting to it, on the other hand, which is not shown here. The feed tube 19 and the beginning of the feed line preferably are at the same elevation as the axis of the feeding cylinders 3 and 5.

Since both control slides are preferably identical, subsequently the control slide 15 is described in lieu in more detail in Fig. 2. Its sections starting with "15" are present at the control slide 17 in the same manner.

The control slide 15 can be positioned within the guidance structure, relative to its longitudinal extension, in three different predefined shifting positions; this is performed through a drive system which is to be discussed later. It also comprises three different functional sections. On top is the inlet section 15 E. It is open towards the prefilling container and towards the feeding cylinder 3, so it has an opening in the direction of its longitudinal axis and another one perpendicular to it. For redirecting the thick material by 90° from the prefilling container into the feeding cylinder, a feed slide 15S, this means a spherically curved gutter section is inserted. Its free cross section preferably corresponds approximately to the cross section of the feeding cylinder 3 and preferably forms a (deflection) angle of 90°. In its place an appropriately angled elbow tube, possibly with an inlet that is expanded like a funnel can be provided and integrated into the structure of the control slide. This inlet section 15E becomes functional, when the control slide 15 within the guidance structure 11 is positioned in its lowest position. At the same time the section 15E is closed on the surface pointing away from the feeding cylinder 3, forming a sealing surface 15D towards the collector tube 19. Thereby it is accomplished, that in the inlet position of the control slide 15 no connection exists to the collector tube, or that

it remains closed also relative to the prefilling container 7. As will become clearer later, this enables a feed operation of the other respective feeding cylinder during the refilling of the one feeding cylinder in the sense of a continuous feed.

Below the inlet section 15E follows a locking- or blocking section 15B of the control slide 15. This only has the purpose of blocking the connection between the feeding cylinder and the collector tube 19, visible to the right of the shift valve, on both sides. When the control slide is in the middle of its three positions, the blocking section 15B lies in front of the opening of the feeding cylinder. After filling with thick material it can perform a short pre compression stroke, in order to adapt the pressure in the freshly filled in thick material to the pressure in the feed line, connected to the collector tube. At the same time a reverse impact onto the pressure in the feed line is avoided through the sealing surface 15D towards the collector tube 19.

The blocking section, which does not have any flow guiding function, will be kept as short as possible, provided that it assures a safe blockage of the feeding cylinders, also against a substantial precompression pressure. An extension of a little more than 250 mm (also a little larger than the diameter of the feeding cylinders) should be sufficient, with exact positioning capability furthermore provided.

At the very bottom in the control slide 15 lies a transfer section 15L, preferably comprising a short, in particular straight tube section, open on both sides having the same interior cross section as the feeding cylinder 3. This adaptation of the shape and size of the transfer section 15L can be seen well in Fig. 2, as well as in Fig.3. During the operation of the shift valve and of the thick material pump it is constantly filled with thick material.

As mentioned above, the mentioned sections can be considered single modules, that can be prefabricated and assembled into a control slide.

Overall the control slides form a 3/3 way valve together with the inlet slides, the openings of the feeding cylinders and the openings of the collector tube as paths, and with the three above described positions.

In Fig. 3 on the right side the geometric layout of the intake section (here 17E) next to the gutter (17S) of the control slide (here 17) on the feeding cylinder (here 5), as well as the position of the sealing surface 17D in front of the opening of the collector tube 19 can be recognized. Here the thick material can flow from the prefilling container 7 only via the slide 17S into the opening of the feeding cylinder 5; the same holds for the respective inlet position of the control slide 15.

Here also the side walls 15W, 17W of the control slides can be seen. These can be completely closed and are preferably made from a suitable flat material. On the top and on the bottom between the respective sections, cross members have to be provided between the side walls, in order to unite these into a stiff box forming the frame for the sections and components of the control slides. This frame e.g. has in the embodiment shown a planform of approximately 300 mm by 300 mm and is approximately 800 – 900 mm tall.

Thereby a width of approximately 300mm is defined by the diameter of the feeding cylinder of 250 mm. The height is determined through the design of the control slide in 3 sections. The depth (dimension in longitudinal direction of the feeding cylinder) given above also at approximately 300 mm, can be adapted to the respective installation requirements, in order to provide an inlet cross section as big as possible for the slides, it should however not be smaller than the cross section of the feeding cylinders themselves.

Furthermore Fig. 3 also shows some design details of the layout of the guidance structure 11, thus the side walls 11W and the middle rim 11M. These form guide surfaces or rails for the control slides 15 and 17. The layout of the details of the guide elements is subject to the choice of appropriate and wear resistant materials and shapes through a person skilled in the art.

In this cut view the shape and the technical function of the collector tube 19 becomes more apparent. It is provided as a Y-tube in a known manner, whose two branches each are connected to a control slide 15 or 17 and its "mouth" or intake flange 20 is directly connected to the feed line, which is not shown in more detail.

The free cross section of the feed line in the mouth area is smaller than in the intake area towards the control slides.

The compactness of the set up due to the directly adjacent control slides can be seen very well in Fig. 4. In this cut view of the guidance structure 11, the control slides 15 and 17 positioned next to each other at different elevations and of the prefilling container 7 it is emphasized, that the bottom of the latter is penetrated by the guidance structure 11. Its bottom 11B is located by 2/3 of the height of the control slides below the bottom of the prefilling container. The walls 11W of the guidance structure and its middle rim are visible in their full extension; they are by about 2/3 longer than the control slides 15 and 17 themselves.

It is not mandatory to provide the walls of the guidance structure in a fully enclosed manner, if the guiding elements for the control slide do not require it. However, for safety reasons (penetration of foreign objects, preventing people from reaching in unintentionally, etc. accident risks) it can be advantageous to keep them closed.

Also a bottom 11B of the guidance structure is shown here as closed. However it can be useful to provide it in a perforated manner, or with a dump flap in order to drain water seeping in between the control slides and the guidance structure and in order to avoid motion restricting air pockets during the downward travel of control slides.

The two feeding cylinders 3 and 5 are located longitudinally in viewing direction, covered behind the guidance structure 11. The control slide 15 is at the same elevation as in Fig. 2 and Fig. 3 this means in its maximum possible (transfer)- posi-

tion. The control slide 17 is also shown in its inlet position according to Fig. 3, its lowest possible position within the guidance structure 11.

Thereby, for the moment the transfer section of the control slide 15 is positioned in front of the opening of the feeding cylinder 3 (located behind it and covered up). The latter is momentarily connected with the collector tube 19 and the feed line in a fluidic manner, so that it can eject the filled in and precompressed thick material.

On the other hand the inlet section 17E of the control slide 17 lies in front of the opening of the feeding cylinder 5, so that the feeding cylinder 5 is connected with the prefilling container 7, so it can be refilled.

In Fig. 5, which will be discussed later, this corresponds to the phase 7 of the motion phases of the shift valve.

At the same time the transfer section 17L of the control slide 17, at its lowest position, is located at the elevation of the flap 13, indicated by a dashed circle (See Fig.1). It should be noted in this context that flaps 13 can be provided for each control slide 15 and 17, and that the flaps 13, due to the close vicinity of both control slides in the guidance structure, can also form a common maintenance and dump flap for both control slides 15 and 17. It would then certainly have to be wide enough to provide unrestricted access (in particular for inserting cleaning bodies) into both control slides (or their respective tubing section). Onto these flap(s) no pressure will be exerted during normal operation, so that they do not have to be very strong, or do not have to be sealed in particular. However they should, as mentioned above, be safely lockable against opening during the operation of the shift valve 9.

It is evident, that through locating the guidance structure 11 at the elevation of the bottom of the prefilling container 7, the advantage can be reaped, that the respective inlet sections of the control slides bridge an elevation difference of the thick materials flow by themselves. As can be seen clearly in Fig. 2, the thick material flows

in from the top and downward following gravity, offset by the height of the inlet section (approximately 250 - 300 mm) sideways (after a deflection of 90° into the feeding cylinder. The real bottom of the prefilling container is therefore located slightly above the openings of the feeding cylinders 3 and 5, hereby basically the advantage of the static pressure in the area of the cylinder openings is used in order to facilitate refilling and sucking in.

The respective middle position of the control slides ("blocking position") lies in the exact middle between the extreme positions of the control slides 15 and 17, shown in Fig. 3. It can either be adjusted and fixated directly through the drives, or additional mechanical locking devices or rests for securing the shifting positions in a defined manner can be provided as mentioned above. The latter however are not shown here.

In Fig. 4 also drive variants mentioned above are shown in a highly schematic manner. On the left, at the control slide 15 a tandem lifting cylinder assembly 21 is provided. Onto a fixed point 23 a first lifting cylinder 25 is mounted, whose rod end piece carries an additional lifting cylinder 27. The rod end piece of the latter is connected through a console 29, which is only shown in principle, with the flat slide 15. Certainly in the guidance structure 11 a longitudinal opening is provided, wherein the console 29 is guided in a sliding manner. Both lifting cylinders are provided in a double acting set up. The lifting cylinder 27 has to be provided with flexible feed lines.

Visibly both rod end pieces of the lifting cylinders 25 and 27 are fully extended. Through reversing one of the rod end pieces, the control slide 15 can initially be brought into its middle position (blocking position). When also the second rod end piece is retracted, the control slide reaches its lower position (inlet position). In reverse moving direction the rod end pieces are then extended one after the other, whereby the strokes of the lifting cylinders 25 and 27, in a suitable set up, jointly define the positions of the flat slide exactly.

On the right side the drive of the flat slide 17 is alternatively provided as a double acting 2 stage telescopic cylinder 31. It is directly located between a fixed point 33 and a console 35, which is only shown in principle, which is in turn is connected with the control slide 17 in a solid manner. It is also moveable in the guidance structure 11 through a longitudinal opening. Since the control slide 17 is in its lowest (inlet -) position, also the lifting cylinder 31 is fully retracted. Through extending its rod end piece into a first stage or lifting position, it positions the control slide 17 in its blocking position, in a second stage, through further extension of the rod end piece, the control slide 17 reaches its transfer position.

Again, with reference to Fig. 2, it becomes apparent in connection with the low position of the control slide 17 in Fig. 2, that after opening the flap, or the flaps 13, thick material still remaining in the tubing sections 15L or 17L (the latter shown in dashed lines) can easily be removed. During normal operation of the shift valve it is certainly not necessary, since this relatively small amount, or column of thick material is ejected again into the collector tube and into the feed line, with the next feed or ejection stroke.

Since the transfer section in this position is completely separated from the feed line, there is no elevated pressure in it. Besides that, it will be assured through appropriate means, that the flap 13 can not be opened when the thick materials pump and the shift valve run during feed operations and that the shift valve can not be shifted while the flap is open.

After opening the flap 13 also a cleaning body 37 (also shown in Fig. 2 in dashed lines) can be inserted into the transfer section 15L or 17L (which have been purged by hand in a suitable manner before). After closing the flap 13 it can be moved in the transfer section through switching the control slide, between the openings of the respective feeding cylinder or the collector tube 19. Subsequently it is run through the collector tube and the feed lines e.g. through compressed air, which is provided through an in feed between the feeding cylinder and the control slide, which is not shown here, in order to purge these lines from remaining thick material.

Through a passage of a cleaning body through both branches of the collector- or Y-tube 19, these two are also purged, whereby the thoroughness of the cleaning of the feed line can be increased through double passage of a cleaning body (subsequently through both branches of the collector tube and then through the common feed line). It is understood, that for both processes the same cleaning body can be used twice, or different cleaning bodies can be used.

Through a suitable shape of the collector tube in the joint area and/or through simultaneous pressurization into both branches of the collector tube 19 it can be assured that the cleaning body does not get caught in the collector tube branch, which has been cleared before, upon its second passage.

With reference to Fig. 5, a time - distance diagram of the feeding pistons and the motion phases of the control slides 15 and 17 of the shift valve 9, after introducing all major parts of the thick materials pump and its periphery, the feed process per se and the controls of the thick materials pump and its shift valve are explained and discussed in detail. The two pistons of the feeding cylinders 3 and 5 are only represented as reference numerals K3 & K5 at the beginning of the respective diagram line. The motion or motion cycle of the piston K3 is shown in a dashed line, the one of the piston K5 in a solid line.

The above mentioned motion phases of the shift valve, whose reduced schematic display corresponds to the view of Fig. 4 are numbered from 1 through 8 and shown next to each other in a diagram plotted over time, and separated from each other through vertical lines.

In phase one both control slides 15 and 17 are in their "transfer position", this means their transfer sections 15L and 17L are located in front of the openings of the feeding cylinders 3 and 5 at the same time (in the following also starting position). Both feeding cylinders 3 and 5 are also connected to the collector tube 19

and the subsequent feed line. None of the feeding cylinders communicates with the pre filling container 7.

According to phase 1 of the diagram the piston K3 of the feeding cylinder 3 moves towards the end of a pumping stroke, while the piston K5 of the (freshly filled) cylinder 5 just starts with a new pump stroke after a pre compression. Both pistons are moved in parallel and in the same direction at a relatively slow speed. This can be called “synchronous motion phase”.

Phase 2 is a transition of the feeding cylinder 3 between the pump stroke and the intake stroke. The control slide 15 was - preferably after stopping the piston K3 - moved downward by half of its total stroke, while the control slide 17 remained stationary. The opening of the feeding cylinder 3 is tightly sealed by the blocking section 15B, its piston K3 stops for a short time before changing its stroke direction (“transition phase”). The feeding cylinder 3 is completely closed relative to the collector tube 19. This in between- or blocking position of the control slide 15 safely avoids any fluidic short cut between the one pumping and the other intaking feeding cylinder.

During this relatively short phase the control slide 15 can move; or it can be stopped temporarily, in case the blocking section 15b, as discussed, is provided very short.

During this time the piston K5 continues to be within its pumping stroke, as can also be seen in the diagram phase 2. But the slope of its motion is steeper now, this means its forward velocity is increased to a normal level (e. g. doubled), compared to the previous synchronous phase 1. Thereby compared to phase 1 a continuous flow of thick material in the feed line is assured.

Phase 3 shows the first extreme relative position of both control slides. The control slide 15 was displaced downward by its total stroke (e.g. by a total of a little more than 500 mm). It is located in its inlet position now; its slide 15S lies in front of the

opening of the feeding cylinder 3, at the same time the control slide 17 is still in its "transfer position", still allowing a feed from the feeding cylinder 5 into the feed line.

The diagram shows in phase 3, that the piston K5 still runs at full speed or with full pumping power, while the piston K3 performs an intake stroke, preferably with a soft start and finish, but overall with a higher speed than in the pump stroke ("intake phase"). Through the normal (weight -) pressure of the thick material in the prefilling container and its hydro dynamically advantageous guides on the slide 15S, the feeding cylinder 3 is filled in an optimal manner.

Also in this phase a temporary stop of the oscillating motion of the control slide 15 can be advantageous, so that the total intake stroke can be performed with the feeding cylinder 3 completely open.

The position of the shift valve 9 in phase 4 of Fig. 5 corresponds to phase 2. The control slide 15 was lifted from its intake position by the first half of its stroke. Now, as can be seen from the diagram, the piston K3 (locked solid again by the blocking section 15B of the control slide 15) of the feeding cylinder 3, can pre compress the thick material through a very short stroke, that has just been taken in with low density, preferably to the current operating pressure in the feed line ("pre compression phase"). This is also recommended with respect to gases taken in with the thick material (air bubbles) and with respect to the counter pressure from the collector tube 19 and the feed line, in order to avoid shocks in the system, when the cylinder opening in the following phase is connected again from the transfer section 15L to the feed stream. Also here the control slide can be stopped temporarily or at least slowed down.

The piston K5 just runs into the end phase of its pump stroke, still with full speed.

Phase 5 exactly corresponds to phase 1 with respect to the position of the shift valve 9 (starting position "synchronous phase"). Also the diagram shows in phase 5, that now the pistons K3 and K5, with exchanged roles (relative to phase 1) re-

commence their phase shifted operation with simultaneous pump feeding at reduced speed. Now begins the motion cycle of the control slide 17.

Phase 6 is a mirror image of phase 2; now only piston K3 pumps at full speed, while the blocking section 17B of the control slide 17 tightly seals the feeding cylinder 5 and its piston K5 rests according to the diagram phase 6. The control slide 17 is shifted downward by half of its total stroke.

Phase 7 is a mirror image of phase 3. As mentioned before, also Fig. 4 shows this phase. The control slide 17 has reached its lowest position. The feeding cylinder 5 is being refilled. Its piston K5 returns according to diagram phase 7 into its starting position and via the slide 17S thick material flows into the feeding cylinder 5. At the same time the feeding cylinder 3 provides full pumping power, its piston K5 is at full forward velocity.

In phase 8, which is a mirror image of phase 4, the piston K5 pre compresses the newly filled in thick material, while the piston K3 reaches the end phase of its pumping stroke. In the diagram a full operation cycle of the two cylinder thick material pump is now completed, the further operation continues again with phase 1.

For emphasizing the velocities, pressures, and forces during the operation of the thick materials pump at continuous feed, it should be mentioned that the total course of the phases 1 - 8 occurs within only 6 seconds, as it is shown through the labeled time axis below the diagram. Thereby the pistons of the feeding cylinders have to go through strokes of approximately one meter length, while the total strokes of the control slides are in a range between 500 mm and 600 mm.

For further interpretation of the diagram of Fig. 5 it should initially be repeated, that in the phases 1 and 5 both pistons simultaneously pump thick material into the collector tube 19 and into the feed line. During these phases their velocities are adjusted relative to each other, so that their total feed volume corresponds to the feed volume of one single piston at normal forward velocity. Thereby, together with the

pre compression phase of the newly starting piston, a practically shock free constant feed volume of the thick materials pump is accomplished.

In all other phases only one of the pistons is in pumping operation, and it then runs preferably at constant speed. The static pressure in the respective non moving branch of the collector tube 19 then corresponds to the pressure in the feed line. It is safely received by the sealing surfaces 15D or 17D of the control slide in its blocking and/or inlet position.

The design of the shift valve according to the invention and a dedicated forward motion control of the feeding pistons makes it possible to accomplish a constant output of the thick materials pump in the phases of the common pump strokes, compared to the single pumping power of a piston, and thereby practically eliminating the pulsation of the thick materials flow in the feed line. This is especially facilitated by the pre compression of the thick material in the phases 4 and 8, thereby avoiding the opening of a freshly filled feeding cylinder 3 or 5, or connecting a pressure free ("buffer space") with the feed line. The volume of the thick material in the "reactivated" transfer section 15L or 17L is negligible with respect to such buffer effect.

Though, thru the pre compression steps (phases 4 and 8) considerable forces are imparted to the control slides 15 and 17, however they are easily received and transferred through their robust and still relatively simple linear slide bearing within the guidance structure 11. Hereby also the advantage of a substantially translatoric slide bearing comes to bear, as well as the advantage of a constant connection of the down stream end of the collector tube 19 with the feed line.

In an advantageous manner the weight of the thick material can support the quick feed via the slide of the control slide towards the cylinder opening to be feed.

The momentary position of the pistons K3 and K5 and of the control slides 15 and 17 can be sensed with suitable sensors (distance sensors, position sensors, pres-

sure sensors), possibly directly at the respective drives. The sensors preferably provide their position signals to a preferably central control unit of the thick materials pump, which in turn controls the drives of the feeding pistons K3 and K5 and of the shift valve 9.

In particular, in moments of simultaneous feed from both feeding cylinders it controls the reduction of their forward velocities. Not necessarily both pistons have to be controlled to half speed, but in principle one piston can be controlled to 1/3 of full velocity and the other one to 2/3 of full velocity (assuming equal diameters and total strokes). The goal remains a feed stream, as constant as possible, of thick material in the feed line.

Furthermore the control unit has to, during the time span, when the freshly filled feeding cylinder is locked by the blocking section of the associated control slide 15 or 17, on the one hand stop the shift valve or adjust it to slower travel, on the other hand control the pre compression stroke of the associated piston. This possibly requires an additional pressure sensor that can be located in the cylinder in the piston, or also in the pressurized branch of the collector tube 19. A blocking of the control slides 15 and 17 through increased pressure during pre compression can certainly be excluded through a pressure limiter.

Also in other phases, e.g. the synchronous phases, the transition phase and the inlet- or suction phase, a reduced speed of the control slides 15 / 17 or even their momentary stand still between the reversal points can be advantageous. Overall one will have to carefully weigh between stand still times and motion times of the control slides, so that on the one hand the available flow cross sections are not reduced too much through overlap of the blocking sections with the openings of the feeding cylinders, on the other hand no excessive slide velocities are required.

For the continuous operation of the thick materials pump it can also be helpful to run through the various slide positions at constant speed without slowing down or stopping.

Fig. 6 once more addresses the control the slide drive 21 with tandem lift cylinders shown in Fig. 4 on the left in more detail. Again, one can see the fixed point 23 provided with a joint (preferably at the housing of the shift valve 9) and the lifting cylinders 25 and 27, both arranged in series on top of each other, as well as the console 29 for the control slide, which is not shown here. The lifting cylinders 25 and 27 are shown here in a schematic cut view so that three motion phases of this drive concept become apparent from the right to the left: on the very left both lifting cylinders are loaded on their rod sides and are in their respective lowest position. Accordingly the control slide is in its inlet position. In the middle phase the lower lifting cylinder 25 is loaded on the piston side and is in its upper position, while the upper lifting cylinder which is moved along, is still loaded on the rod side (blocking position of the control slide). The third phase shows both lifting cylinders in piston loaded, fully extended position (transfer position of the control slide). For lowering the latter the phases are performed in reverse direction. With reference to the respective, previously discussed positions of the control bodies in the previous figures the three phases in Fig. 6 - 8 are designated with the letters E (inlet position), B (blocking position) and L (transfer position).

Fig. 7 shows the same process with a two stage telescopic cylinder 31, as shown in Fig. 3 on the right side. The fixed point 33 which is attached to the housing of the shift valve 9 with a pivotable joint, carries the lifting cylinder, which is connected to a control slide through a console 35, with its rod. Again 3 working positions of the lifting cylinder 31 are provided, wherein for the middle position an additional stop or blocking mechanism is provided, in order to make this position approachable in a defined manner. A hydraulic locking of this middle position directly in the lifting cylinder 31 could also be realized, but might not be adjustable exactly enough in demanding continuous operations. In practice a small lifting cylinder 39 is provided here, which is mounted to the housing of the shift valve in a solid manner, possibly via an additional fixed console and whose rod end piece can be extended into the travel of the telescopic cylinder 31.

In Fig. 7 one can see again from the left to the right, analogous to Fig. 6 three motion phases, or positions E, B and L. On the very left the telescopic cylinder is loaded on the rod side and is in its lowest position. The blocking cylinder 39 is retracted. In the middle the telescopic cylinder is semi extended; its rod end piece abuts to the meanwhile also extended rod end piece of the blocking cylinder 39, so that here the intermediate position (blocking position) is reached. In the right phase the blocking cylinder 39 is retracted again, so that the way for the rod of the telescopic cylinder 31 into the upper most, fully extended (stop -) position is free. Accordingly also the control slide (not shown) which is connected via the console, is now in its uppermost (transfer-) position L.

Fig. 8 shows an equivalent to Fig. 7, this means a two stage controllable long stroke lifting cylinder 41, associated with a blocking cylinder 43. The fixed point 33 and the console 35 are identical to Fig. 6 and 7. Again, on the very left, the long stroke lifting cylinder 41 is loaded on the rod side in its lowest possible position E. The blocking cylinder 43 is retracted. During the transition of the lifting cylinder 41 (now loaded on the piston side) into its middle position (B) also the blocking cylinder 43 is extended, so that its rod end piece enters into the path of the rod end piece of the lifting cylinder 41, blocking it in the middle position. On the very right in Fig. 8, the blocking cylinder 43 is retracted again and the rod of the lifting cylinder 41 can be extended in its uppermost position (L).

Also in the configurations according to Fig. 7 and 8, certainly for downward motion of the associated control slide, the reverse sequence of the previously discussed motion phases or positions is required, what is being controlled through rod side loading of the lifting cylinders.

It is understood that the blocking cylinders 39 and 43 with the respective lifting cylinders or rod end pieces have to be adjusted in any case in a manner, so that also during the upward travel of the lifting cylinders the middle position is exactly adjustable. The schematically simplified arrangements shown in here only serve for better understanding of the working principle of these drives, but do reflect the real in-

stallation conditions and the cooperation between the lifting and blocking cylinders only on a limited basis.